

A person wearing a plaid shirt is holding a long, silver, rectangular LI-191R Line Quantum Sensor. The sensor is held horizontally, extending from the left side of the frame towards the right. The background is a blurred green field. In the lower-left corner, a portion of a black data logger with a keypad and a small screen is visible.

# LI-191R Line Quantum Sensor

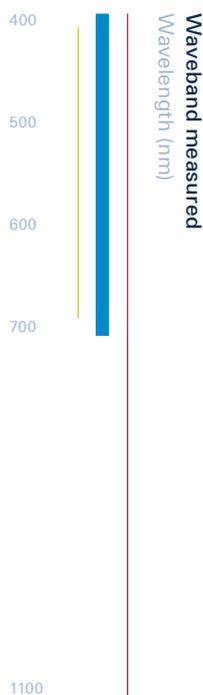
The LI-191R Line Quantum Sensor measures PAR integrated over its 1-meter length. It is used to measure sunlight under a plant canopy, where the light field is non-uniform. The LI-191R makes it easy to measure under-canopy light in many plots quickly and consistently. It measures light in units of Photosynthetic Photon Flux Density (PPFD), which is expressed as  $\mu\text{mol s}^{-1} \text{m}^{-2}$ .

## Why choose the LI-191R?

- Improved water resistance for long-term outdoor deployment
- Integrated measurements using a single detector prevents variance found in sensors that use multiple detectors
- Selected by the National Ecological Observatory Network (NEON®) for integrated PAR measurements

## How does it work?

The LI-191R uses a 1-meter long quartz rod under a diffuser to direct light to a single filtered silicon photodiode. The entire LI-191R diffuser is sensitive to light over its 1-meter length. Since the diffuser is one continuous piece, the LI-191R essentially integrates an infinite number of points over its surface into a single value that represents light from the entire 1-meter length. Optical filters block radiation with wavelengths beyond 700 nm, which is critical for under-canopy measurements, where the ratio of infrared to visible light may be high. The unique design of the LI-191R provides an excellent quantum response that is close to the ideal quantum response.



### LI-191R Line Quantum Sensor Specifications

- Absolute Calibration:  $\pm 10\%$  traceable to National Institute of Science and Technology (NIST). The LI-191R is calibrated via transfer calibration using a reference LI-190R Quantum Sensor. Transfer error is  $\pm 5\%$  (included in the  $\pm 10\%$ )
- Sensitivity: Typically  $7 \mu\text{A}$  per  $1,000 \mu\text{mol s}^{-1} \text{m}^{-2}$
- Linearity: Maximum deviation of  $1\%$  up to  $10,000 \mu\text{mol s}^{-1} \text{m}^{-2}$
- Response Time:  $10 \mu\text{s}$
- Temperature Dependence:  $\pm 0.15\%$  per  $^{\circ}\text{C}$  maximum
- Cosine Correction: Acrylic diffuser
- Azimuth:  $< \pm 2\%$  error over  $360^{\circ}$  at  $45^{\circ}$  elevation
- Operating Temperature Range:  $-40^{\circ}\text{C}$  to  $65^{\circ}\text{C}$
- Relative Humidity Range:  $0\%$  to  $95\%$  RH, Non-Condensing
- Sensitivity Variation over Length:  $\pm 7\%$  maximum using a  $2.54 \text{ cm}$  ( $1''$ ) wide beam from an incandescent light source.
- Sensing Area:  $1 \text{ m} \times 12.7 \text{ mm}$  ( $39.4'' \times 0.50''$ )
- Detector: High stability silicon photovoltaic detector (blue enhanced)
- Sensor Housing: Weatherproof anodized aluminum housing with acrylic diffuser and stainless steel hardware.
- Size:  $121.3 \text{ L} \times 2.54 \text{ W} \times 2.54 \text{ cm D}$  ( $47.7'' \times 1.0'' \times 1.0''$ )
- Weight:  $1.4 \text{ kg}$  ( $3.0 \text{ lbs.}$ )
- Cable Length:  $2 \text{ m}$ ,  $5 \text{ m}$  ( $6.5'$ ,  $16.4'$ )

Specifications subject to change without notice.

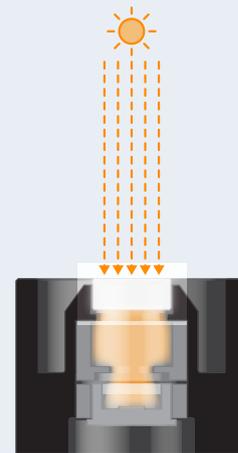
# Science

LI-COR terrestrial light sensors are cosine-corrected, following Lambert's cosine law. A cosine-corrected sensor provides the most accurate measurements of radiation on a flat surface from all angles. Cosine correction ensures accurate measurements under various conditions such as low light levels and low solar elevation angles.

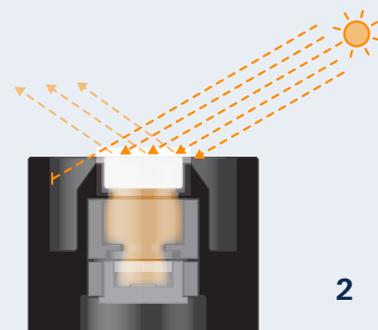
The design of the sensor creates the proper cosine response at angles of incidence up to  $82^\circ$ . Radiation is received by an acrylic disc called a diffuser, or "eye". When radiation strikes with a greater angle of incidence, more is received by the edge of the diffuser. This compensates for increasing reflection from the top surface as the angle of incidence grows larger. Beyond an angle of about  $80^\circ$ , the rim of the sensor begins to block some light in order to maintain the correct response as more radiation is received by the edge of the diffuser. At a  $90^\circ$  angle of incidence, the rim completely blocks the diffuser, in keeping with a proper cosine response.

LI-COR light sensors create the proper cosine response at various angles of incidence.

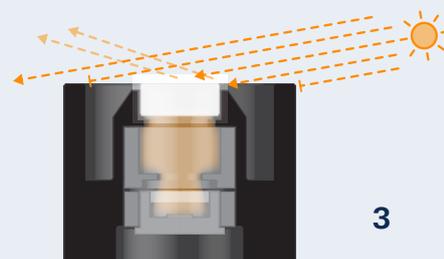
1.  $0^\circ$ : Light is received only by the top surface of the sensor eye.
2.  $60^\circ$ : Light is received by the edge of the eye, compensating for increasing reflection from the top.
3.  $80^\circ$ : The rim of the sensor begins to block some light, preventing too much from striking the edge.
4.  $90^\circ$ : The rim completely blocks the sensor eye, in keeping with a proper cosine response.



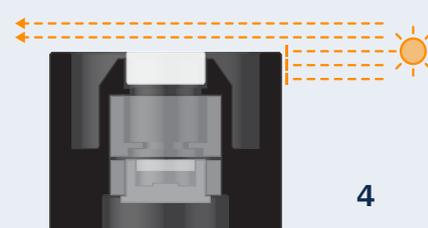
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### LI-COR Calibration Standards

Calibration is an integral step in the manufacture of all LI-COR optical radiation-measuring instruments. Because of slight variation in internal optical components, it is necessary to characterize each individual sensor before it leaves LI-COR. This calibration data is supplied as a "calibration constant," which indicates the amount of sensor output for a given amount of measurable energy input.

Calibration constants are used to convert the raw signal into the appropriate units of solar radiation. A readout device such as the LI-1500 Light Sensor Logger or LI-250A Light Meter can store calibration multipliers to do this conversion automatically. Other loggers and meters must have their data scaled by a factor determined from the calibration constant to derive the appropriate units.

The characteristics of the optical components may be affected by environmental conditions. We recommend recalibration every two years to ensure correct measurements.

### Pyranometer Calibration

LI-200R Pyranometers are calibrated against an Eppley® Precision Spectral Pyranometer (PSP) under natural daylight conditions. Calibration uncertainty under these conditions is estimated as  $\pm 3\%$  typical, within  $\pm 60^\circ$  angle of incidence.\*

### Quantum Sensor Calibration

Quantum sensors, including the LI-190R, LI-191R, LI-192, and LI-193, are calibrated using working standard quartz halogen lamps, which have been calibrated against reference standard lamps traceable to the U.S. National Institute of Standards and Technology (NIST). The absolute calibration specification for quantum sensors is  $\pm 5\%$  (typically  $\pm 3\%$ ) traceable to NIST.

### Photometric Sensor Calibration

The LI-210R photometric sensors are calibrated using 683 lumens per watt as a value of spectral luminous efficiency at a wavelength of 555 nm. This value conforms to the recommendations of the International Committee for Weights and Measures (CIPM). Calibration is performed using working standard quartz halogen lamps, which have been calibrated against reference standard lamps traceable to the NIST.

\*Preliminary specification

Specifications subject to change without notice.

# Ordering Information

## Sensors

### Terrestrial Sensors

**Sensor:** LI-190R Quantum Sensor, LI-200R Pyranometer, or LI-210R Photometric Sensor

**Cable length:** 2 m, 5 m, 15 m, or 50 m

**Termination type:** BNC, bare leads, millivolt adapter, or SMV (Standard Output Millivolt Adapter)

### LI-191R Line Quantum Sensor

Each LI-191R includes a bubble level and carrying case.

**Cable length:** 2 m or 5 m

**Termination type:** BNC, Millivolt Adapter, or SMV (Standard Output Millivolt Adapter)

### Underwater Quantum Sensors

**Sensor:** LI-192 Underwater Quantum Sensor or LI-193 Spherical Underwater Quantum Sensor

**Cable length:** 3 m, 10 m, 30 m, 50 m, or 100 m

**Termination type:** BNC or Millivolt Adapter

## Logger and Meter

### LI-1500 Light Sensor Logger

The LI-1500 connects up to three light sensors with BNC terminals. Includes four AA batteries, USB cable, AC power supply adapter, carabiner clip, carrying case, Windows® file viewer software. Sensors sold separately.

### LI-1500G Light Sensor Logger with GPS

GPS-enabled.

### LI-1500G-UW Light Sensor Logger with GPS – Underwater Package

GPS-enabled. Includes underwater lowering frame and carrying case for underwater light sensors, lowering frame, and cables.

### LI-1500-UW Light Sensor Logger – Underwater Package

LI-1500 without GPS. Includes underwater lowering frame and carrying case for underwater light sensors, lowering frame, and cables.

### LI-250A Light Meter

Connects to any light sensor with a BNC terminal and displays instantaneous or 15-second averaged measurements.

## Accessories

### 1500GPS Upgrade Kit

User-installable upgrade adds GPS functionality to any LI-1500.

### 1500-01 Underwater Carrying Case

Case holds one LI-1500, underwater lowering frame, two LI-192 Underwater Quantum Sensors, two LI-193 Spherical Underwater Quantum Sensors, one terrestrial sensor (LI-190R, LI-200R, or LI-210R), and 3-meter or 10-meter underwater cable.

### LI-250A Carrying Case

Fabric case for the LI-250A and one light sensor.

### 2001S Sensor Base Cover

Protects the base and cable when the sensor head is removed.

### 2003S Mounting and Leveling Fixture

For the LI-190R, LI-200R, and LI-210R Sensors. Anodized aluminum with stainless steel leveling screws and a weatherproof spirit level. 7.6 cm diameter (3.0") and 95 g (0.21 lbs.).

### 2009S Lowering Frame

Mounts one or two LI-192SA or LI-193SA sensors for lowering into water.

### 2420 Light Sensor Amplifier

Amplifies signal from light sensors. For use with logging devices that require an amplified voltage signal. Provides 15 gain settings to accommodate a wide variety of data loggers.

**2420-BNC** – For light sensors with BNC connectors.

**2420-BL** – For light sensors with bare leads.

### Millivolt Adapters

Convert BNC connector to bare leads and the output signal to millivolts (mV). For use with logging devices that require a voltage signal. SMV-type adapters feature a standard output (0 to 10 mV) so that multipliers do not need to be changed when changing sensors. SMV-type adapters are factory adjusted to match a particular sensor's output. Provide the sensor's serial number when ordering.

**2220 Millivolt Adapter** – For the LI-200R Pyranometer.

**2290 Millivolt Adapter** – For the LI-190R Quantum Sensor, LI-210R Photometric Sensor, and LI-191R Line Quantum Sensor.

**2291 Millivolt Adapter** – For the LI-192SA and LI-193SA Underwater Sensors.

**2320 (SMV)** – For the LI-200R Pyranometer.

**2319 (SMV)** – For the LI-190R Quantum Sensor or LI-191R Line Quantum Sensor.

**2321 (SMV)** – For the LI-210R Photometric Sensor.